IMAGE PROCESSING APPARATUS, IMAGE PROCESSING METHOD, STORAGE MEDIUM AND PROGRAM

BACKGROUND OF THE INVENTION

5   Field of the Invention

The present invention relates generally to an image processing apparatus for extracting a characteristic value for a transformation of gradation, and more particularly to an image

10 processing apparatus for extracting the characteristic value from an image in which pixel values are rearranged based on magnitudes of the pixel values.

Related Background Art

15   In a case where data obtained from photographing by some photographing apparatus such as a sensor, a camera, etc. are displayed on a monitor screen, an X-ray diagnosis film, etc., it is general that the photographed data are subjected to some

20 gradation transformation, wherein the acquired data are converted into easy-to-observe density values. For example, FIGS. 3A and 3B are views schematically showing a radiation image of the abdomen, wherein the numeral 301 represents a spinal region, the numeral

25 302 denotes a gas generated in the abdomen, and the numeral 303 indicates a region from which a characteristic value for the gradation transformation

is extracted. The characteristic value has hitherto been calculated from pixel values in the region 403, and the gradation transformation has been conducted based on this characteristic value.

5   There might be, however, a case where a gas assuming a complicated configuration is produced in the abdomen, and this gas region extends over the region for calculating the characteristic value for the gradation transformation. Such being the case, a

10   magnitude of the characteristic value might largely differ depending on a case where the gas extends over the region for calculating the characteristic value and on a case where it does not. A problem arises from this, wherein a scatter in density of the image

15   after the gradation transformation occurs.

What has been described so far is how the prior art is, and it is therefore desired to provide an image processing apparatus capable of stably performing the gradation transformation of an object

20   image with a high accuracy.

SUMMARY OF THE INVENTION

It is a primary object of the present invention, which was devised to obviate the aforementioned

25   problems inherent in the prior arts, to provide an image processing apparatus comprised of sorting means for executing sorting processing of sorting a train

of pixel values within the same line of a radiation image and thus rearranging the train of pixel values within the same line from pixels having higher pixel values to pixels having lower pixel values, analyzing

5   means for calculating a characteristic value from a predetermined region of the image after the sorting processing, and gradation transforming means for executing gradation transformation processing of the radiation image based on the characteristic value.

10   Other features and advantages of the present invention will be apparent from the following descriptions taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts

15   throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

        The accompanying drawings, which are incorporated in and constitute a part of the

20   specification, illustrate embodiments of the invention, and together with the descriptions, serve to explain the principle of the invention, in which:

        FIG. 1 is a block diagram showing a construction of an embodiment 1 of the present

25   invention;

        FIG. 2 is a flowchart showing a processing flow in the embodiment 1; and

FIGS. 3A and 3B are views showing how an image of the abdomen is subjected to sorting processing.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

5   A preferred embodiment of the present invention will be described in detail in accordance with the accompanying drawings.

(Embodiment 1)

FIG. 1 shows an X-ray photographing apparatus

10   100 according to an embodiment 1 of the present invention. Namely, the X-ray photographing apparatus 100 is an X-ray photographing apparatus having an image processing function. The X-ray photographing apparatus 100 includes a preprocessing circuit 106, a

15   CPU 108, a main memory 109, a control panel 110 and an image processing circuit 111, wherein pieces of data are transferred to and received from each other via a CPU bus 107.

Further, the X-ray photographing apparatus 100

20   includes a data acquisition circuit 105 connected to the preprocessing circuit 106, a two-dimensions X-ray sensor 104 connected to the data acquisition circuit 105, and an X-ray generation circuit 101, wherein these circuits are connected also to the CPU bus 107.

25   In the thus constructed X-ray photographing apparatus 100, to begin with, the main memory 109 is stored with various categories of data required for

process in the CPU 108, and includes a work memory
for operations of the CPU 108.

The CPU 108 controls the operations of the
whole apparatus in accordance with control given from
5   the control panel 110, and so forth. Under this
control, the X-ray photographing apparatus 100
operates as follows.

To start with, the X-ray generation circuit 101
irradiates a subject 103 with X-ray beams 102.
10   The X-ray beams 102 irradiated from the X-ray
generation circuit 101 penetrate the subject 103
while being attenuated, then reach the two-dimensions
X-ray sensor 104, and are outputted as an X-ray image
from the two-dimensions X-ray sensor 104. Herein,
15   the X-ray image outputted from the two-dimensions X-
ray sensor 104 is assumed to be a human body part
image of, e.g., the abdomen, etc..

The data acquisition circuit 105 converts, into
electric signals, the X-ray image outputted from the
20   two-dimensions X-ray sensor 104 and supplied the
converted electric signals to the preprocessing
circuit 106. The preprocessing circuit 106 executes
preprocessing such as offset correction processing,
gain correction process, etc. on the signals (X-ray
25   image signals) from the data acquisition circuit 105.
The X-ray image signals having undergone the
preprocessing in this preprocessing circuit 106 are

transferred as an original image to the main memory
109 and to the image processing circuit 111 via the
CPU bus 107 under the control of the CPU 108.

The numeral 111 represents a block diagram
5 showing a construction of the image processing
circuit, wherein the numeral 112 designates an
irradiation region recognition circuit for extracting
a region of the two-dimensions X-ray sensor 104,
which is directly irradiated with X-rays, the numeral
10 113 denotes a crosswise direction sorting circuit for
sorting a train of pixel values according to
magnitudes of the pixel values within the same line
of the image in the irradiated region extracted by
the irradiation region recognition circuit 112, the
15 numeral 114 represents an analysis circuit for
calculating a characteristic value from a
predetermined region of the image that have been
subjected to the sorting processing in the crosswise
direction sorting circuit 113, and the numeral 115
20 stands for a gradation transformation circuit for
performing a gradation transformation of the original
image on the basis of the characteristic value
calculated by the analysis circuit 114.

FIG. 2 is a flowchart showing a processing flow
25 in the embodiment 1. FIG. 3A represents an image of
the abdomen. FIG. 3B shows a view in which the sort
process is executed outwards in the crosswise

direction by the crosswise direction sorting circuit 114. In FIGS. 3A and 3B, the numeral 301 represents the spinal region, the numeral 302 denotes a gas generated in the abdomen, and the numeral 303

5   indicates a region from which the characteristic value for the gradation transformation is extracted. Similarly, in the image after the sorting processing, the numeral 304 represents the spinal region, the numeral 305 stands for a gas generated in the abdomen,

10 and the numeral 303 indicates a region from which the characteristic value for the gradation transformation is extracted.

Next, an operation of the image processing circuit 111 will be explained in accordance with the

15 processing flow in FIG. 2.

The irradiation region recognition circuit 112, which has received the input image processed by the preprocessing circuit 106 via the CPU bus 107 under the control of the CPU 108, extracts the irradiated

20 region in the input image (step S201). In this case, a region excluding the irradiation region region recognized by the irradiation region recognition circuit 112, is set as a zero (0) pixel value. Then, the crosswise direction sorting circuit 113 extracts

25 a train of the pixel values from the same line of the image, and sorts the train of pixel values on the basis of the magnitudes of the pixel values. For

instance, as in the image depicted in FIG. 3B, the
pixel value train is sorted so that lower pixel
values are disposed at a left end portion in the
image (S202). Whatever methods may be taken as this
5   sorting method as far as the sorting processing is
generally applied. The crosswise direction sorting
circuit 113 executes the sort process described above
over the all the lines of the image. The 0 pixel
value in the image is, however, set at the right end.
10   An image of limbs, a bone part region being
poor of a transmissivity of the X-rays and resulting
in a low pixel value, has a property that the pixel
value increases towards a through-region from the
bone part. Furthermore, the gas region has a
15   tendency of exhibiting a high transmissivity of the
X-rays and a high pixel value. Therefore, in the
case of executing the sorting processing within the
horizontal lines of the image, the bone part region
defined as the low pixel value part concentrates at
20   the left end portion of the image, while soft tissues
proximal to the gas part region, viz., the through-
region concentrates at the right end portion of the
image. The same effect is exhibited also in an image
of a chest part, etc., wherein an image of the spinal
25   region concentrates at the left end, while an image
of a lung field region and the through-region
concentrate at the right end portion.

Thus, the value of the pixel value differs in accordance with anatomical parts (the bone part, the gas part, the soft part, etc.) of the subject, and hence the tissues and the gas part within the subject

5   can be easily separated by executing the sorting processing (304 and 305 in FIGS. 3A and 3B). Moreover, even in a case where the subject is obliquely photographed, the separation of the gas part can be made with a stability without taking a

10   posture of the subject into consideration.

Next, the analysis circuit 116 calculates a characteristic value such as an average value from a predetermined region (a square region 306 in FIGS. 3A and 3B) separated at a fixed distance from the left

15   end portion in the image (S203). In this case, it is preferable that the fixed distance from the left end portion be given in the right side of the spinal region 304, and hence the gradation transformation circuit 115 makes a gradation transformation of the

20   original image based on this characteristic value as well as on the general characteristic value of the spine (S204).

According to the embodiment 1, the image intra-line pixel values undergo the sorting processing,

25   there is produced the effect enabling the spinal part region and the gas part region to be easily separated. Therefore, the gas part region can be removed from

the region where the characteristic value for the
gradation transformation is to be calculated, thereby
yielding an effect of stabilizing the density of the
image after the gradation transformation. Further,
5   in the case of making use of only the image within
the irradiation region, an effect is that the
characteristic value can be stably calculated even
when performing a narrow-down of the irradiation
region without being affected by the low pixel value
10   region outside the irradiation region. Furthermore,
the region spaced at the fixed distance away from the
end portion of the sorted image is set as the region
where the characteristic value is to be calculated,
thereby producing the effect that the characteristic
15   value can be calculated from the region extending
over neither the spinal region nor the gas region.
(Other Embodiment)

Note that the present invention may be applied
to either a system constituted by a plurality of
20   apparatuses (e.g., image processing apparatuses,
interfaces, radiographic apparatuses, X-ray
generation apparatuses, and the like) or an
arrangement that integrates an image processing
apparatus and a radiographic apparatus, or the like.
25   Further, the object of the present invention
can also be achieved by providing a storage medium
storing program codes for performing the aforesaid

processes to a computer system or apparatus (e.g., a personal computer), reading the program codes, by a CPU or MPU of the computer system or apparatus, from the storage medium, then executing the program.

5   In this case, the program codes read from the storage medium realize the functions according to the embodiment, and the storage medium storing the program codes constitutes the invention.

Further, the storage medium, such as a floppy
10 disk, a hard disk, an optical disk, a magneto-optical disk, CD-ROM, CD-R, a magnetic tape, a nonvolatile type memory card, and ROM can be used for providing the program codes.

Furthermore, besides aforesaid functions
15 according to the above embodiment area realized by executing the program codes which are read by a computer, the present invention includes a case where an OS (operating system) or the like working on the computer performs a part or entire processes in
20 accordance with designations of the program codes and realizes functions according to the above embodiment.

Furthermore, the present invention also includes a case where, after the program codes read from the storage medium are written in a function
25 expansion card which is inserted into the computer or in a memory provided in a function expansion unit which is connected to the computer, CPU or the like

contained in the function expansion card or unit
performs a part or entire process in accordance with
designations of the program codes and realizes
functions of the above embodiment.

5   In a case where the present invention is
applied to the aforesaid storage medium, the storage
medium stores program codes corresponding to the
flowchart shown in FIG. 2 described in the embodiment.

       The present invention is not limited to the
10   above embodiments and various changes and
modifications can be made within the spirit and scope
of the present invention. Therefore to apprise the
public of the scope of the present invention, the
following claims are made.

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